IHI Mortality Measurement Meeting

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Data Source

- TR Projected Inpatient Data Base (PIDB)
  - Combines data from both public and proprietary state data as well as individual and group hospital contracts
  - The construction of the PIDB involves the application of sophisticated data screens to ensure quality
  - Contains more than 20 million all-payer discharges throughout the U.S. from over 2,700 acute care hospitals (about half of the actual discharges that occur in the U.S. annually)
  - Statistically projected using stratified sampling weight information to the entire U.S. population of acute care inpatient discharges
  - The PIDB has been used for many peer-reviewed publications
  - Comprised of administrative data

Data Source (continued)

- Selected peer-reviewed articles published from PIDB data
  - Young JK, Foster DA, Heller ST. Cardiac revascularization in specialty and general hospitals. *N Engl J Med*. 2005 Jun 30;352(26):2754-6
  - Belay ED, Holman RC, Maddox RA, Foster DA, Schonberger LB. Kawasaki Syndrome Hospitalizations and Associated Costs in the United States. *Public Health Reports*. 2003 Sep-Oct;118(5):464-9
  - Foster DA, Heller ST, Young JK. Increasing Prevalence of Resistant Streptococcus among Hospital Inpatients in the United States. *N Engl J Med* 2001 344:1329-31 (correspondence)
  - Young JK, Foster DA. Use of Cardiovascular Procedures after Acute Myocardial Infarction in Patients with Mental Disorders. *JAMA*. 2000 283(24):3198; (correspondence) discussion 3198-9
  - Sullivan KM, Delay ED, Durbin RE, Foster DA, Nordenberg DF. Epidemiology of Reye Syndrome, United States, 1991-1994: Comparison of CDC surveillance and hospital admissions data. *Neuroepidemiology* 2000 19(6):338-44

TR Risk-Adjusted Mortality Model (RAMI)

- Comprised of four standard logistic regression models
  - Less than 65 years of age, surgical
  - Less than 65 years of age, medical
  - 65 or more years of age, surgical
  - 65 or more years of age, medical
- ICD-9-CM diagnosis and procedure codes that are considered intervening events, such as hospital-acquired complications, are excluded
- A post-modeling adjustment based on AHRQ CCS categories created from principal diagnosis is used to reduce the compression that typically results from regression models
- Produces an expected probability of death for each patient

TR Risk-Adjusted Mortality Model (RAMI)

- Patient-level risk factors
  - Age, sex, admission source, admission type
  - Principal diagnosis, all other diagnoses codes, all procedure codes (ICD-9-CM) through use of risk-tables
    - Principal diagnosis
    - Secondary diagnosis with highest risk
    - Procedure code with highest risk
    - Interaction between principal and secondary with highest risk
    - Interaction between principal and procedure with highest risk
- Hospital-level adjustment factors (optional)
  - Bed size category
  - Teaching status
  - Urban/rural community setting
  - Census division

RAMI Facility Exclusions

- Long-term care facilities (typical Medicare discharge length of stay greater than 25 days)
- Cancer specialty hospitals
- Psychiatric, Substance Abuse, and Rehabilitation specialty hospitals
- Federally owned or controlled facilities
- Hospitals that are missing identified characteristics or have fewer than 6 beds

RAMI Patient Exclusions

- Invalid or incomplete data
- Inconsistent age, sex, diagnosis or procedure code interactions
- Encounter for palliative care
- DRG Not Surgical Or Medical
- DRG 468 Extensive OR Procedure Unrelated To Principal Diagnosis
- DRG 477 Non-extensive OR Procedure Unrelated To Principal Diagnosis
- Other (Appendix C in RAMI white paper)

RAMI Example Of Risk Table

DX code	PDX lt 65	SDX lt 65	PDX ge 65	SDX ge 65
0023	0	0	-1	0.502717
0029	0	0	-1	0
0030	0.00145	0.002344	0.002676	0.012117
0031	0.014157	0.087099	0.06673	0.149798
00322	0	0.390412	0	0
00323	0	0.251	0	0.088008
00324	0	0.069085	0	0

Model Performance Metrics

- Sensitivity measures the percent of patients correctly classified among those that experience the outcome
- Specificity refers to the percent of patients correctly classified among those that did not experience the outcome
- Percent correct describes the percentage of patients whose predicted outcome matches their actual experience, regardless of whether or not they experienced the outcome
- C-Statistic: the area under a receiver operating characteristic (ROC) curve (maximum area = 1.0)

ICD-9-CM Exclusions as Intervening Events

- Diagnosis code examples (from a total of 83)
  - 2513 Post surgical hypoinsulinemia
  - 3240 Intracranial abscess
  - 3241 Intraspinal abscess
  - 3249 Intracranial and intraspinal abscess of unspecified site
  - 38330 Postmastoidectomy complication, unspecified
  - 41511 Iatrogenic pulmonary embolism and infarction
  - 45821 Hypotension of hemodialysis
- Procedure code examples (from a total of 14)
  - 0123 Reopening of craniotomy site
  - 0302 Reopening of laminectomy site
  - 0475 Revision of previous repair of cranial and peripheral nerves
  - 0602 Reopening of wound of thyroid field
  - 1152 Repair of postoperative wound dehiscence of cornea
  - 1266 Postoperative revision of scleral fistulization procedure

Model Performance Results

Model	Rate	c-statistic	% correct	sensitivity	specificity
Medical , age > = 65	4.43%	0.915	85.4	76.8	89.6
Medical, age < 65	0.97%	0.978	94.5	90.8	94.9
Surgical , age >= 65	2.51%	0.963	91.7	87.7	92.7
Surgical, age < 65	0.76%	0.986	95.7	94.7	95.8

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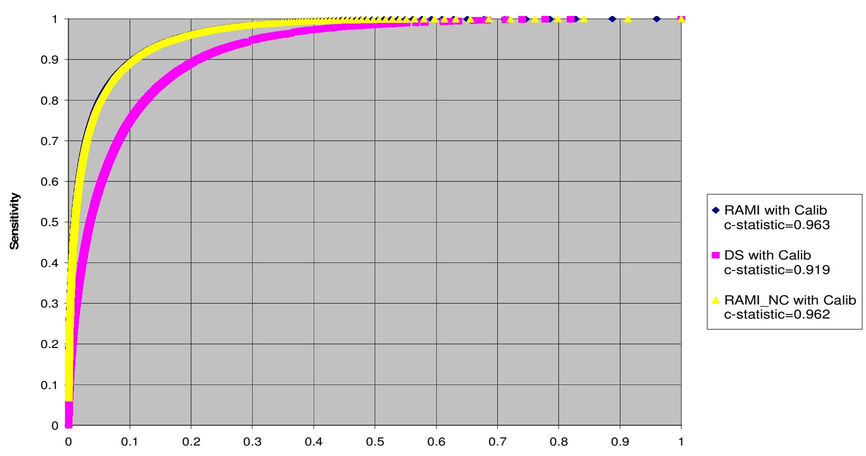
RAMI versus Disease Staging (DS) Mortality Results (ROC Curve)

Fig 1-5. ROC Graph of RAMI and Disease-Staging for In-Hospital Death



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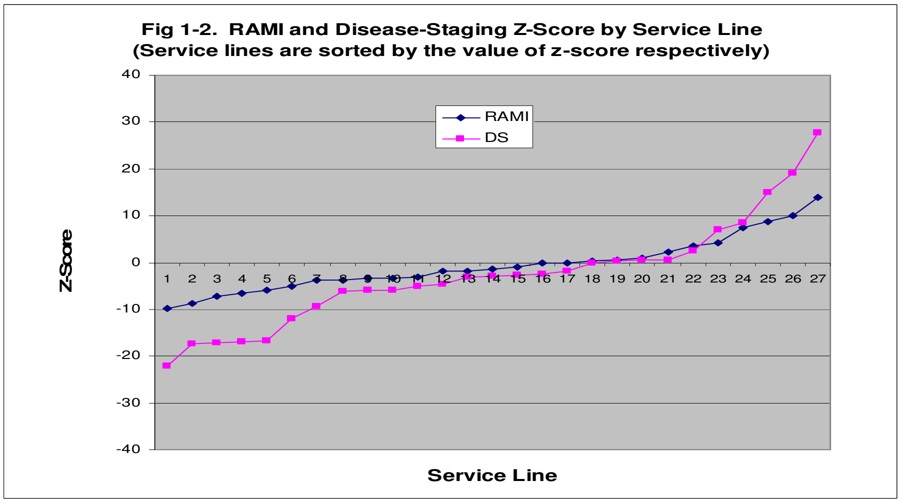
RAMI versus DS Mortality Results (continued):



RAMI versus DS Mortality Results (continued):

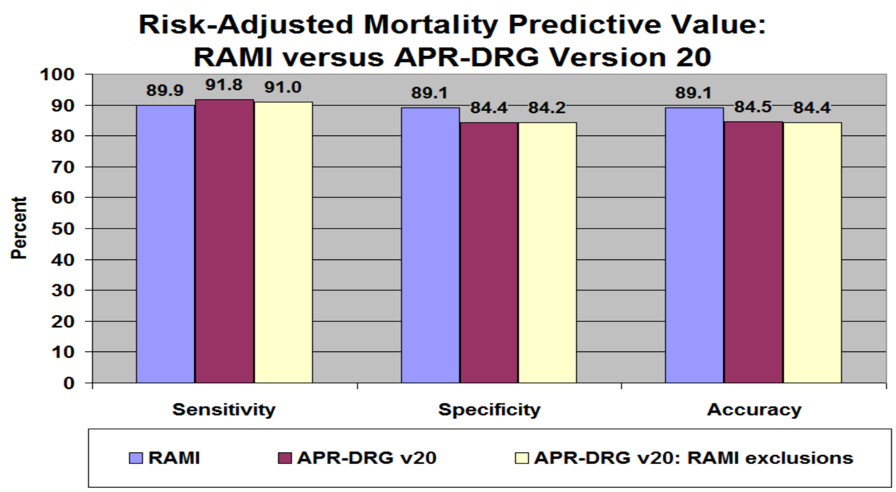
Spearman Correlation between Observed and Expected mortality – Patient Level

	RAMI-Exp vs. Obs	DS-Exp vs. Obs	DS-Exp vs. RAMI-Exp
Spearman Coefficients	0.34419 (p<0.0001)	0.24710 (p<0.0001)	0.56867 (p<0.0001)

Pearson Correlation between Observed and Expected mortality by DRG

	RAMI-Exp vs. Obs	DS-Exp vs. Obs	DS-Exp vs. RAMI-Exp
Pearson Coefficients	0.99241 (p<0.0001)	0.93435 (p<0.0001)	0.93373 (p<0.0001)

RAMI versus APR-DRG Mortality Results:



RAMI Performance as Described by External Investigators

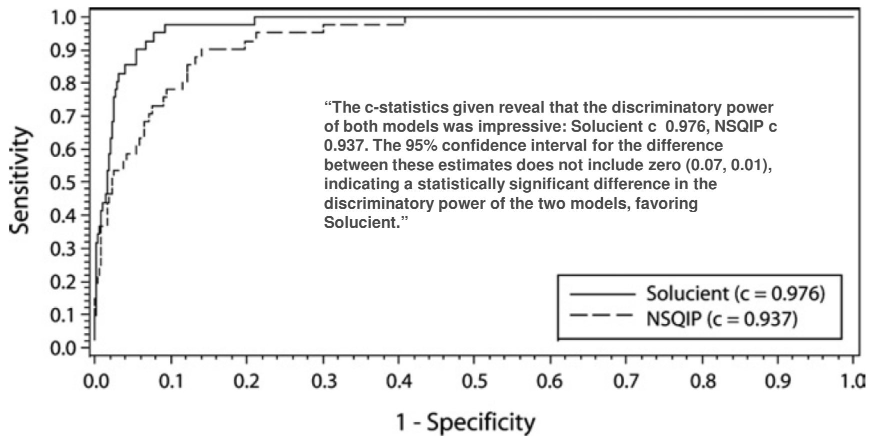
Hall BL, Hirbe M, Waterman B, Boslaugh S, Dunagan WC.

Comparison of mortality risk adjustment using a clinical data algorithm (American College of Surgeons National Surgical Quality Improvement Program) and an administrative data algorithm (Solucient) at the case level within a single institution.

J Am Coll Surg. 2007;205:767-777.

Conclusions: Risk-adjusted mortality estimates were comparable using administrative or clinical data. Minor performance differences might still have implications. Because of the potential lower cost of using administrative data, this type of algorithm can be an efficient alternative and should continue to be investigated.

RAMI versus NSQIP Mortality Results



Source: Hall BL, et al, J Am Coll Surg 2007;205:767–777.

Conclusions

- The RAMI methodology demonstrates high predictive value in comparing actual deaths with expected deaths
- RAMI compares favorably with other risk-adjustment methodologies in terms of predictive value
- RAMI benefits from a large calibration database that enables comprehensive consideration of interactions between principal diagnosis, other diagnoses and procedures
- RAMI post-modeling adjustment does appear to mitigate the effects of model compression in comparison with a similar methodology that did not address compression